Appendix B

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR WELDING FUMES

INTRODUCTION

This guideline summarizes pertinent information about welding fumes for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine whether new information is available.

SUBSTANCE IDENTIFICATION

* Formula

Varies.

* Structure

(For Structure, see paper copy)

* Synonyms

Synonyms vary depending on the specific components of the fumes.

* Identifiers

1. CAS No.: None.

2. RTECS No.: ZC2550000

3. Specific DOT number: None

4. Specific DOT label: None

* Appearance and odor

Welding fumes are the fumes that result from various welding operations. The primary components are oxides of the metals involved such as zinc, iron, chromium, aluminum, or nickel. Welding fumes typically have a metallic odor, and their specific composition

varies considerably.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: Varies.

2. Boiling point: Varies.

3. Specific gravity: Varies.

4. Vapor density: Varies.

5. Melting/Freezing point: Varies.

6. Vapor pressure: Varies.

7. Solubility: Varies.

8. Evaporation rate: Not applicable.

* Reactivity

1. Conditions contributing to instability: None reported.

2. Incompatibilities: None reported.

3. Hazardous decomposition products: None reported.

4. Special precautions: None reported.

* Flammability

The National Fire Protection Association has not assigned a flammability rating to welding fumes.

1. Flash point: Not applicable.

2. Autoignition temperature: Not applicable.

3. Flammable limits in air: Not applicable.

4. Extinguishant: Use an extinguishant that is suitable for the materials involved in the surrounding fire.

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EXPOSURE LIMITS

* OSHA PEL

The Occupational Safety and Health Administration (OSHA) does not currently regulate welding fumes.

* NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for welding fumes (and total particulates) of the lowest feasible concentration. NIOSH considers welding fumes potential occupational carcinogens [NIOSH 1992].

* ACGIH TLV

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned welding fumes (not otherwise classified) a threshold limit value (TLV) of 5 milligrams per cubic meter (mg/m(3)) as a TWA for a normal 8-hour workday and a 40-hour workweek [ACGIH 1994, p. 36].

* Rationale for Limits

The NIOSH limit is based on the risk of cancer and respiratory disease [NIOSH 1992].

The ACGIH limit is based on the risk of toxic effects caused by welding fumes [ACGIH 1991, p. 1726].

HEALTH HAZARD INFORMATION

* Routes of Exposure

Exposure to welding fumes can occur through inhalation and eye contact.

* Summary of toxicology

1. Effects on Animals: Welding fumes can cause non-specific changes in the lungs; in addition, there is limited evidence for genotoxicity in in vitro test systems. Rats exposed by inhalation or intratracheal instillation of welding fumes from mild-steel welding showed non- specific pulmonary changes with no signs of fibrosis over a period of 450 days [IARC 1990]. The primary effects observed included particle- laden macrophage aggregates, and alveolar epithelial thickening with proliferation of granular pneumocytes [IARC 1990]. Similar changes were observed in the lungs of rats exposed to 1,000 mg/m(3) for 1 hour or to 400 mg/m(3) for 30 minutes/day, six days/week over a two-week period [IARC 1990]. Welding fumes were not associated with an increased incidence of genotoxicity in 11 of 15 in vitro assays, and in all three in vivo tests performed for genotoxicity [IARC 1990].

2. Effects on Humans: Exposure to welding fumes from mild steel is associated with the development of a benign pneumoconiosis, "arc welder's siderosis". This condition is a reversible pneumoconiosis and no associated respiratory signs may be present at the

time the pneumoconiosis is discovered [Rom 1992]. Respiratory impairment has been observed in workers exposed to mild steel welding fumes, but these impairments may be the result of exposure to other toxicants in the working environment, such as crystalline silica [Rom 1992]. Exposure to welding fumes can result in metal fume fever; this condition resembles influenza and is characterized by fever, chills, headache, nausea, shortness of breath, muscle pain, and a metallic taste in the mouth [Rom 1992]. The respiratory effects appear to be potentiated by smoking. There is an excess of infertility among welders that led to studies on sperm quality and welding exposures. There appears to be an increased frequency of abnormalities in semen quality associated with duration of exposure. Abnormalities were highest among stainless steel welders. While hypotheses exist, the mechanism of action resulting in infertility is not known [Rom 1992; IARC 1990]. IARC concluded that there is limited evidence in humans for the carcinogenicity of welding fumes and gases [IARC 1990]. This conclusion was based primarily on a review of 11 cohort studies and 12 case-control studies on lung cancer; only three of these studies (all cohort studies) specifically examined manual metal arc welding of iron, mild steel, or aluminum. Two of the cohort studies found no association between welding fumes and cancer. The remaining cohort studies showed an increased risk for lung cancer, which in some may have been inflated due to selection bias. Ten out of twelve case- control studies showed an association between lung cancer and exposure or employment as a welder. Two of the studies found no risk [IARC 1990]. IARC's final conclusion was that welding fumes are possibly carcinogenic to humans [IARC 1990].

* Signs and symptoms of exposure

1. Acute exposure: Acute exposure to welding fumes can result eye, nose, and throat irritation, fever, chills, headache, nausea, shortness of breath, muscle pain, and a metallic taste in the mouth.

2. Chronic exposure: Chronic exposure to welding fumes can result in respiratory effects including coughing, wheezing, and decreased pulmonary function.

EMERGENCY MEDICAL PROCEDURES

* Emergency medical procedures: [NIOSH to supply]

5. Rescue: Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the Material Safety Data Sheet required by OSHA's Hazard Communication Standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures, the location and proper use of emergency equipment, and methods of protecting themselves during rescue operations.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve welding fumes and lead to worker exposures to these substances:

* Welding operations involving various types of welding equipment and metals

Methods that are effective in controlling worker exposures to welding fumes, depending

on the feasibility of implementation, are as follows:

- Process enclosure
- Local exhaust ventilation
- General dilution ventilation
- Personal protective equipment

Workers responding to a release or potential release of a hazardous substance must be protected as required by paragraph (q) of OSHA's Hazardous Waste Operations and Emergency Response Standard [29 CFR 1910.120].

Good sources of information about control methods are as follows:

1. ACGIH [1992]. Industrial ventilation--a manual of recommended practice. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. Industrial ventilation--a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.

5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL SURVEILLANCE

OSHA is currently developing requirements for medical surveillance. When these requirements are promulgated, readers should refer to them for additional information and to determine whether employers whose employees are exposed to welding fumes are required to implement medical surveillance procedures.

* Medical Screening

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work- related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures. To detect and control work-related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the term of employment, and (3) at the time of job transfer or termination.

* Preplacement medical evaluation

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Before a worker is placed in a job with a potential for exposure to welding fumes, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the respiratory system. Medical surveillance for respiratory disease should be conducted using the principles and methods recommended by the American Thoracic Society.

A preplacement medical evaluation is recommended to assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to welding fumes at or below the prescribed exposure limit. The health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with diseases of the respiratory system.

* Periodic medical evaluations

Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to welding fumes exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of welding fumes on the respiratory system. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population.

* Termination medical evaluations

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of placement should be repeated at the time of job transfer or termination to determine the worker's medical status at the end of his or her employment. Any changes in the worker's health status should be compared with those expected for a suitable reference population. Because occupational exposure to welding fumes may cause diseases with prolonged latent periods, the need for medical surveillance may extend well beyond the termination of employment.

* Biological monitoring

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. No biological monitoring test acceptable for routine use has yet been developed for welding fumes.

WORKPLACE MONITORING AND MEASUREMENT

Determination of a worker's exposure to airborne welding fumes is made using a mixed cellulose ester (MCE) filter, 0.8 microns. Samples are collected at a maximum flow rate of 2.0 liters/minute until a maximum collection volume of 960 liters is reached. Analysis

is conducted by inductively coupled argon plasma (ICP/DCP-AES). This method (ID-125G) is described in the OSHA Computerized Information System [OSHA 1994] and is fully validated. NIOSH Method No. 7300 can also be used to determine a worker's exposure to welding fumes. This method is similar to the OSHA method described above [NIOSH 1994b].

PERSONAL HYGIENE PROCEDURES

Workers should not eat, drink, use tobacco products, apply cosmetics, or take medication in areas where welding fumes are generated.

SPECIAL REQUIREMENTS

U.S. Environmental Protection Agency (EPA) requirements for emergency planning, reportable quantities of hazardous releases, community right-to- know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

* Emergency planning requirements

Welding fumes are not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (SARA) (Title III) in 42 USC 11022.

* Reportable quantity requirements for hazardous releases

A hazardous substance release is defined by EPA as any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of contaminated containers) of hazardous substances. In the event of a release that is above the reportable quantity for that chemical, employers are required to notify the proper Federal, State, and local authorities [40 CFR 355.40].

Employers are not required by the emergency release notification provisions in 40 CFR Part 355.40 to notify the National Response Center of an accidental release of welding fumes; there are no reportable quantity for these substances.

* Community right-to-know requirements

Employers are not required by EPA in 40 CFR Part 372.30 to submit a Toxic Chemical Release Inventory form (Form R) to EPA reporting the amount of welding fumes emitted or released from their facility annually.

* Hazardous waste management requirements

EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Under the Resource Conservation and Recovery Act (RCRA) [40 USC 6901 et seq.], EPA has specifically listed many chemical wastes as hazardous. Although welding fumes is not specifically listed as a hazardous waste under RCRA, EPA requires employers to treat waste as hazardous if it exhibits any of the characteristics discussed above.

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Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (703) 412-9810 (in the Washington, D.C. area) or toll-free at (800) 424-9346 (outside Washington, D.C.). In addition, relevant State and local authorities should be contacted for information on any requirements they may have for the waste removal and disposal of this substance.

RESPIRATORY PROTECTION

* Conditions for respirator use

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of welding fumes exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should only use respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

* Respiratory protection program

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's Respiratory Protection Standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, respirator fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information on the selection and use of respirators and on the medical screening of respirator users, consult the latest edition of the NIOSH Respirator Decision Logic [NIOSH 1987b] and the NIOSH Guide to Industrial Respiratory Protection [NIOSH 1987a].

PERSONAL PROTECTIVE EQUIPMENT

Workers should use appropriate personal protective clothing and equipment that must be carefully selected, used, and maintained to be effective in preventing skin contact with welding fumes. The selection of the appropriate personal protective equipment (PPE) (e.g., gloves, sleeves, encapsulating suits) should be based on the extent of the worker's potential exposure to welding fumes. There are no published reports on the resistance of various materials to permeation by welding fumes.

To evaluate the use of PPE materials with welding fumes, users should consult the best available performance data and manufacturers' recommendations. Significant differences have been demonstrated in the chemical resistance of generically similar

PPE materials (e.g., butyl) produced by different manufacturers. In addition, the chemical resistance of a mixture may be significantly different from that of any of its neat components.

Any chemical-resistant clothing that is used should be periodically evaluated to determine its effectiveness in preventing dermal contact. Safety showers and eye wash stations should be located close to operations that involve welding fumes.

Splash-proof chemical safety goggles or face shields (20 to 30 cm long, minimum) should be worn during any operation in which a solvent, caustic, or other toxic substance may be splashed into the eyes.

In addition to the possible need for wearing protective outer apparel (e.g., aprons, encapsulating suits), workers should wear work uniforms, coveralls, or similar full-body coverings that are laundered each day. Employers should provide lockers or other closed areas to store work and street clothing separately. Employers should collect work clothing at the end of each work shift and provide for its laundering. Laundry personnel should be informed about the potential hazards of handling contaminated clothing and instructed about measures to minimize their health risk.

Protective clothing should be kept free of oil and grease and should be inspected and maintained regularly to preserve its effectiveness.

Protective clothing may interfere with the body's heat dissipation, especially during hot weather or during work in hot or poorly ventilated work environments.

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